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EFFECTS OF FAT, OIL AND GREASE (FOG) DISCHARGE POLLUTANTS ON WATER QUALITY OF QALYASAN STREAM, TANJERO RIVER AND IMPACT OF FAT, OIL AND GREASE ON DARBANDIKHAN RESERVOIR IN SULAIMANI CITY-KURDISTAN REGION OF IRAQ-IRAQ

AHMED I. KHWAKARAM

Faculty of Agricultural Sciences, Sulaimani University, Kurdistan Region of Iraq, Iraq

Original Article

ABSTRACT

Darbandikhan reservoir, Tanjero River and Qalyasan Stream are one of the largest water sources in Sulaimani Governorate intensively used for human uses and irrigation. Today, with increasing the population in Sulaimani Governorate, the water for human consumptive is increased which causes an increase in sewage effluents. This may consequently the high effluence level of fat, oil and grease (FOG) into the Qalyasan stream and Tanjero River without any treatment causing health and environmental impact. The present study aimed to shows the effect of (FOG) pollution on quality of the surface water and to estimate the suitability of water for human uses and irrigation purposes. To monitor the surface water of Darbandikhan reservoir, Tanjero River and Qalyasan Stream, water samples are collected from 9 sites at maximum flow in Qalyasan Stream (S1) during March 2015 (raining season-Winter) till the water flow are closed to zero on July 2015 (dry season-Summer). The results indicate that the quality of water sample at site (S1) is suitable for human uses after conventional treatment and irrigation that are within the permissible limits of (FOG). So, the lowest values of WQIs was obtained at site (S1), while the water at sites S2, S3, S4, S5, S6, S7, and S8 are unsuitable for human uses and less suitable for irrigation, except the water at site S5 was found unsuitable (unfit) for irrigation due to the discharge of high amount of untreated wastewater with high level (FOG), Finally WOI for site (S9) in Darbandikhan reservoir was unfit and good class for human uses and irrigation respectively, this may be due to increase (FOG) in June and July cause degraded water quality of Darbandikhan reservoir.

KEYWORDS: Fat, Oil and Grease (FOG), Water Quality Index (WQI), Qalyasan Stream, Tanjero River, Darbandikhan Reservoir, Untreated Wastewater

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INTRODUCTION

In recently years, quality of surface water especially freshwater became a critical issue in Iraq Kurdistan Region (IKR) or Iraq, therefore freshwater resources must be protected by intensive performance quality monitoring program for surface water (Pesce and Wunderlin 2000) Monitoring of water quality used to measure the condition of the chemical, physical and biological characteristics of water and describe the suitability of water for drinking, irrigation …etc., therefore WQI is an important and useful method for assessing the suitability of water quality (Diersing 2009), (Sarganokar and Deshpande 2003), (Khan *et al* 2003) and (Johanson*et al* 1997). WQI is easily usable by managers and public due to summarize large amount of water quality data into simple terms i.e. excellent,

good, bad etc. (Gangwar *et al* 2013). The water quality index (WQI) was applied to show the impact of FOG which loading in untreated wastewater discharge into fresh water resources (Stream, River and reservoir). The concentration of dispersed FOG is an important parameter for water quality and safety. Water polluted by FOG can cause surface films and leading to aquatic environmental degradation and human health risks.

The sewer system in Sulaimani city discharge untreated wastewater which polluted with FOG into along Qalyasan stream and Tanjero River. FOG comes from different sources such as oil refinery, car washing, restaurants, hotels, spillage oil over roads (Lan*et al* 2009), also slaughterhouses, and dairy industries producing effluents containing high amount of Fat, oil and grease (El-Bestawy*et al* 2005). Oil and grease in water come from petroleum derivatives and fats from vegetable oil and meat processing (Kiely 1997), which comprise a wide variety of organic compounds having different physical, chemical and toxicological properties including fat, soaps, fatty acids, hydrocarbon, waxes and oils (Viessman and Hammer 1998), which have the greater solubility in an organic solvent than in watertherefore to determine oil and grease in water uses gravimetric analytical methods to measure quantify oil and grease compounds (Concentration of oil and grease is greater than 10 mg L^{-1} is possible use standard gravimetric analysis of the extract).

FOG concentration range between 50 to 100 mg L^{-1} in an untreated wastewater come from urban (Techobanglous and Franklin 1995).FOG content should not exceed 10 mg L^{-1} before discharging them into inland surface water or irrigable land according to FEPA (1991). This should not exceed 2 mg L^{-1} for human uses and aquatic life such as recreation (bathing, swimming, skin diving etc.) and drinking water after conventional treatment (coagulation, sedimentation, filtration and disinfection etc.), also for propagation of balance growth of fish and other aquatic resource (National Surface Water classification criteria NSWCC 2007).

Phenols, petroleum hydrocarbons, polyaromatic hydrocarbons are toxic substances associated with fatty and oily wastewater which inhibitory growth of plant and animal, and causes carcinogenic to a human being (Lan*et al* 2009). Also it causes ecology damages for aquatic organisms (Islam*et al* 2013). On the other hands, vegetable oil classified as hazardous pollutants if it mixes with the aquatic ecosystem and become toxicity to the aquatic organisms (Mendiola*et al*1998).

Untreated industrial and municipal wastewater used for irrigation system (Friedler 2004) and (Travis*et al*2008), which content high amount of FOG may cause many problems for the quality of soil and crops (IPD 2008) andTravis*et al* (2008) showed that the accumulation of oil and grease up to 200 mg kg^{-1} in the first 20 cm soil depth, when irrigated with domestic wastewater. This consequently led to a significant reduction in the soils ability to transmit water.

Fat, oil and grease decreases dissolved oxygen levels and increases BOD (Sahu*et al*2007) in the water body due to formation of an oil layer on the water surface and prevent oxygen transfer from the atmosphere. This will lead to a reduction of the biological activity of treatment process where oil film formation around microbes in suspended matter and water (Alade *et al*2011) and (Facchin *et al*2013).

This aim of this study is to focus on periodical monitoring of wastewater effluent to Qalyasan stream and Tanjero River that containing (FOG) resulting from the vegetable oil obtained from plant and animal and/ or from other sources like oil refiner, car washing. So the effect of Fat, oil and grease (FOG) on a reservoir of Darbandikhan will be studied. Also the investigation will be to evaluate the water quality of Qalyasan Stream and Tanjero River based on the some Physio-Chemical characteristics.

MATERIALS AND METHODS

1-DESCRIPTION OF THE SAMPLE SITES

The study area lies between latitude 35°34'59"- 35°13'06" N and Longitude 45°22'41" - 45°51'48" E is located in the NW to SE of Sulaimani city and elevated 485 -787 m above sea level (Figure 1). They include the Tanjero River, Qalyasan Stream and Darbandikhan reservoir. Tanjero River is a permanent River formed by linking two streams (Major stream-Qalyasan and Minor stream-Kani-Ban) and another discharge added water to this River that is sewage effluent (such as Industrial area, Albisaka, Qalawa, Wluba and shekh-Abbas and bakrajo boxes), and geographically located between 35°35′01″- 35°19′05″ N and 45°21' 39″- 45°50′27″ E in Sulaimani city/Iraq. Tanjero River before discharge in Darbandikhan reservoir linking with some other small tributaries such as Kane Shaswaer and Bestansur. Qalyasan stream is ephemeral stream (recently years disappears during summer) formed by linking Chaq-Chaq stream and Sarchinar springs, in addition to untreated wastes of industrial area and Sulaimani oil refining foundation discharge in the stream, and geographically located between 35°35′01″- 35°28′44″ N and 45°21' 39″- 45°26′17″ E in Sulaimani city/Iraq. On the other hand, Darbandikhan reservoir is discharged to Diyala River which is one of the great tributaries of Tigris River.

In order to assess water quality and estimate the effect of FOG content in these water resources, nine sites were chosen along the stretch of the Qalyasan Stream, Tanjero River and within Darbandikhan reservoir (Figure 1). The water samples were collected form sites of S1, S2, S3 and S4 along the Qalyasan stream (Table 1), and sample site S5, S6, S7 and S8 were collected along the Tanjero. However the final sample site S9 was collected directly within Darbandikhan reservoir according to Twin Rivers Institute Work (2008), which is a more polluted area in Darbandikhan reservoir. The overall distance between the sampling sites S1 to S9 was about (75 km).

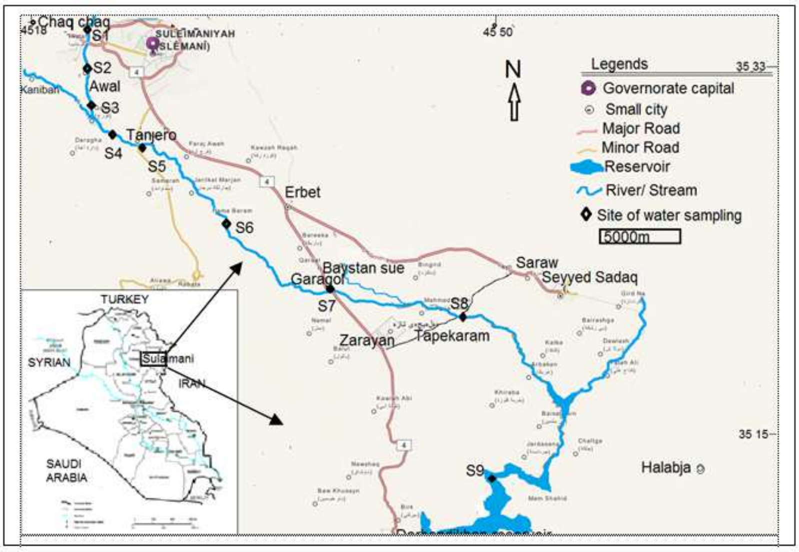


Figure 1: A Map of the Study Area Showing the Different Sampling Sites of Qalyasan Stream, Tanjero and Darbandikhan Reservoir

Table 1: Geographical of Water Sampling Sites

Longitude	Latitude	Description	Sites
45° 22' 41"E	35° 34' 59"N	Qalyasan stream-Near to the Sarchinar Cement Factory	S1
45° 21' 55"E	35° 33' 17"N	Qalyasan stream- Near to Awabara bridge	S2
45° 22' 22"E	35° 31' 33"N	Qalyasan stream- Near to KaniGoma bridge	S3

Table 1: Contd.,			
45° 23' 14"E	35° 29' 55"N	Qalyasan stream-Near kurd city apartments	S4
45° 25' 36"E	35° 28' 44"N	Tanjero River-Under Tanjero bridge	S5
45° 29' 56"E	35° 26' 07"N	Tanjero River- Near to Erbet destruct-damarkan factory	S6
45° 37' 36"E	35° 24' 20"N	Tanjero River- Under Garagol bridge	S7
45° 45' 05"E	35° 20' 14"N	Tanjero River -Under bridge Tapekaram	S8
45° 51' 48"E	35° 13' 06"N	Within Darbandekhan reservoir-Pirmahamad	S9

Laboratory Analysis

The water samples were collected in sterilized bottles according to standard methods of APHA (1998) during March 2015 to July 2015. The samples were analyzed as per standard methods for the Physiochemical parameters namely; Temperature, pH, EC and turbidity determine by portable meters immediately at all sites. Total dissolved solids (TDS) were computed by multiplying the EC (in μScm^{-1}) by a factor of (0.64). However the parameters of calcium, magnesium and sodium were determined according to the standard method of APHA (1998). Total hardness (TH) determined according to the procedure given by Theroux*et al*(2001) Sodium adsorption ratio (SAR) was estimated by the equation described byRyan *et al*(2001). The solvent extraction method was used for fat, oil and grease determination, according to Best and Ross (1977) fat, oil and grease and other extractable materials were dissolved in petroleum ether 40-60°C under acidic condition and separated from the aqueous phase. The solvent layer was then evaporated, oven dried at 70°C and the residue weighted as fat, oil and grease in mg L^{-1}.

Calculating of Water Quality Index (WQI)

Cude (2001) calculated the Water Quality Index (WQI) by using the Weighted Arithmetic Index method and (WQI) calculated by using these expressions.

$$Qi = [(Vactual - Videal)/(Vs\tan dard - Videal)]*100 \quad (1)$$

Where,

Qi = Quality rating of (i) the parameter for a total of (n) water quality parameters

V actual = Actual value of the water quality parameter obtained from laboratory analysis

V ideal = Ideal value of that water quality parameter can be obtained from the standard Tables. For pH = 7 and other parameters it is equaling to zero

V standard = Standard of the water quality parameter for human uses and for irrigation purposes.

$$Wi = 1/Si \quad (2)$$

Where,

- Wi = Relative (unit) weight for (n) th parameter
- Si = Standard permissible value for (n)th parameter

$$WQI = \sum QiWi / \sum Wi \quad (3)$$

In this study the suitability of WQI for human uses and irrigation purposes are taken as 300 score and five range

of water quality.

RESULTS AND DISCUSSIONS

Water Quality Index (WQI)

The values of various physicochemical parameters of sampling water for Qalyasan stream, Tanjero River and Darbandikhan reservoir are shown in tables (2, 3, 4, 5 and 6). Water Quality Index (WQI) have been calculating form physicochemical parameters for maximum flow of Qalyasan Stream at the months of March/2015, because the highest discharges are coincided with rained period in Sulaimani city, and for the months May, April, June. The water flow was near to zero at the month July /2015. The suitability of WQI values for human uses and irrigation was rated as follows; < 50 represents excellent quality; 50- 100 Good quality; 100-200 Poor quality; 200-300- Very Poor quality; > 300 Unsuitable quality (unfit), according to standard values for human uses of different parameters such as Temperature pH, EC, Turbidity, TDS, Ca^{2+}, Mg^{2+}, Na^{+}, hardness, oil and grease recommended by GOB (1997), NSWCC (2007), WHO (2004), AWQQ (1981), IQS (2001) and ICMR (1975) and FEPA (1991). The standard values for irrigation purposes of temperature, pH, EC, Turbidity and TDS Ca^{2+}, Mg^{2+}, Na^{+}, hardness, oil and grease recommended by GOB (1997), AWQQ (1981), FEPA (1991)and FAO (1985), and electrical conductivity 1500 $\mu S\ cm^{-1}$ according to SAR < 3 ,as shown in table 7. The results of the comparative of WQI values for human uses and irrigation purposes in March have the lowest WQIs for Qalyasan stream fresh water sample in the site (S1). The WQI is increased sharply on July at site S5 which polluted with untreated wastewater and consequently discharge to the Darbandikhan reservoir (S9) this coinciding with the beginning of the irrigation season and increased water demanding for human uses in Sulaimani city. It is observed that the value of WQI for Qalyasan stream in site (S1) is varied from 125.6 and 31.3 in March to 217.8 and 47.0 in July for human uses and irrigation purposes respectively, therefore WQI for Qalyasan stream was suitable for human uses after conventional treatmentand ranged in poor class (100-200) in March to very poor class (200-300) in July and for irrigation purposes was ranged in excellent class (<50) in March and July with some degraded in water quality in July. According to Hallock (2002), Water quality increasing with the rise of water dischargein the March.While the WQI at sites S2, S3, S4, S5, S6, S7, and S8 are unsuitable for human uses and ranged in unfit class (>300) and less suitable ranged in good class (50-100) in March and poor class (100-200) in July for irrigation purposes as shown in figures 2 and 3, except the water quality at site S5 was found unfit (>300) in July for irrigation purposes. Therefore WQI for Tanjero River is unsuitable for human uses and for irrigation purposes. This study shows a cleardecrease in water quality during the summer period,although not as dramatic as the drop in River flow.These results are an agreement with the similar result obtained by Mustafa (2006) in Tanjero River clearly shows WQI categorized under pollute class for drinking, and Barros*et al*(1995) finding similar results for a single year.Thus, a general progressive increase in WQI values, along the Tanjero River, due to the discharge of various domestic and industries wastewater along thestretch. The values of WQI for Darbandikhan reservoir at site (S9) which was polluted area varied from (304.8) and (55.6) in March to (359.6) and (71.8) in July for human uses and irrigation purposes respectively, therefore WQI in Darbandikhan reservoir at site (S9) for human uses ranged in unfit class (>300) was non suitable, but required primary and secondary treatment, These results are in agreement with result reported by Nature Iraq/Twin Rivers Institute Work (2008). It had been shown that Darbandikhan reservoir polluted by Tanjero River which loaded with high untreated wastewater and this lead to degraded water quality in the reservoir, while for irrigation purposes ranged in good class (50-100).

The changes in water temperature from March when the water flow at maximum to July the water flow closed to zero at different sites of Qalyasan stream, Tanjero River, and Darbandikhan reservoir were changed from (14.3°C to 25.3°C), (14.3°C to 28.6°C) and (16.0°C to 29.3°C) at sites (S1), (S5) and (S9) respectively, during the study period (Tables 2 to 5). The suitable temperature range of water for irrigation is 20 – 30°C (GOB 1997) and 25°C for drinking water according to WHO (2004) and WHO (1984).The temperature fluctuation depended upon the ambient temperature that directly effect on surface water in Qalyasan stream, Tanjero River and Darbandikhan reservoir. Seasonally, water temperature was highest in summer followed by a cold winter season.

The results of pH values of water samples were shown in tables (2 to 5) of all sites were lies in the alkaline side of neutrality due to the geological formation of the area which composed mainly of $CaCO_3$. The lowest value (7.04) was found at the site (S4) and the highest value (7.90) was found at the site (S9). According to WHO (1984) and Ayers and Westcot (1976) the desirable limit for pH is 7.0-8.5 which is a safe range for human uses and irrigation purposes. On the other hands, Conductivity is another important factor effect on water quality measurement, because it gives a good idea to the amount of dissolved salts in the water (Nabi 2005). It is approximately proportional to the TDS content (Tebbutt 1977). The mean values of EC and TDS were shown in tables (2 to 5) and indicated that the values changed from (1137.3 µS cm^{-1}) and (727.87 mg L^{-1}) to (1663.9µScm^{-1}) and (1064.9 mgL^{-1}) in March and July respectively. From results the mean values of turbidity for water sample in all sites were increased from (52.11 NTU) in March to (125.06, 242.09, 254.73 and 268.00 NTU) in April, May, June and July respectively. The water samples were found to be more turbid during the summer months. This may be due to the reducing water body, more waste discharge, urban domestic activities, algal growth etc…,. The lowest mean value of turbidity was observed in (S1) (2.12 NTU) during March and it was lower than the WHO standard of 5 NTU and 50 NTU for human uses and irrigation purposes respectively, while the higher value was observed in (S5) (887 NTU) during July was higher than the WHO standard for human uses and irrigation purposes.

Table 2: Physiochemical Parameter Values for All Sampling Sites on 7th March 2015

	Sites									
Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**Mean**
Temp. °C	14.3	13.5	13.8	14.1	14.3	14.0	14.1	15.5	16	14.40
pH	7.22	7.32	7.23	7.29	7.28	7.15	7.19	7.33	7.43	7.27
EC µS cm^{-1}	693	904	861	1293	1498	1150	1867	1136	832	1137.3
TDS mg L^{-1}	443.6	578.5	551.1	827.8	959.0	736.2	1195.1	727.0	532.6	727.87
Turb. NTU	2.12	37.8	35.3	87.4	166	39.4	67.4	21.2	12.4	52.11
Ca^{2+} mg L^{-1}	122.15	138.15	136.15	203.15	230.15	166.15	260.15	158.15	120.15	170.48
Mg^{2+} mg L^{-1}	7.68	13.88	10.98	18.58	22.48	18.18	32.68	17.48	16.48	17.60
Na^{+} mg L^{-1}	3.95	19.28	17.58	15.38	22.88	32.38	44.28	39.78	19.28	23.87
FOG mg L^{-1}	4.0	12.8	16.0	23.6	34.8	15.6	18.8	11.6	8.8	16.22
TH mg L^{-1}	336.49	401.94	385.01	583.52	666.96	489.52	783.81	466.67	367.71	497.96
SAR	0.07	0.30	0.28	0.20	0.27	0.45	0.49	0.57	0.31	0.33

Table 3: Physiochemical Parameter Values for All Sampling Sites on 5th April 2015

	Sites									
Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**Mean**
Temp. °C	14.3	14.8	19.5	19.6	19.8	21.0	21.2	22.3	23.5	19.56
pH	7.44	7.55	7.41	7.34	7.35	7.20	7.31	7.43	7.53	7.40
EC µS cm^{-1}	754	954	921	1184	1511	1066	1164	1080	991	1069.5
TDS mg L^{-1}	482.6	610.8	589.6	758.0	967.2	682.4	744.9	690.9	634.0	684.5
Turb. NTU	6.16	33.5	42.6	335	327	100	229	37.7	14.6	125.06
Ca^{2+} mg L^{-1}	134.15	161.15	148.15	189.15	239.15	156.15	166.15	156.15	148.15	166.48

Table 3: Contd.,

Mg^{2+} mg L^{-1}	8.48	11.98	11.38	14.78	19.88	15.98	17.98	15.58	17.78	14.87
Na^{+} mg L^{-1}	2.88	6.58	16.78	19.18	23.38	31.28	35.58	34.68	20.18	21.17
FOG mg L^{-1}	4.8	14.4	17.2	35.6	62.4	25.2	31.2	14.8	9.2	23.87
TH mg L^{-1}	369.73	451.53	416.61	532.94	678.72	455.51	488.70	453.86	442.95	476.73
SAR	0.05	0.10	0.25	0.26	0.28	0.45	0.50	0.50	0.30	0.30

Table 4: Physiochemical Parameter Values for All Sampling Sites on 9th May 2015

	Sites									
Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**Mean**
Temp. °C	17.1	19.3	21.5	20.3	21.3	20.9	22.3	23.2	24.1	21.11
pH	7.24	7.28	7.41	7.04	7.05	7.26	7.31	7.23	7.33	7.24
EC µS cm^{-1}	767	795	1025	1735	1769	1324	1366	1217	701	1188.8
TDS mg L^{-1}	491.2	508.9	656.0	1110.5	1132.1	847.2	874.0	778.8	448.7	760.8
Turb. NTU	2.22	176	55.7	883	634	80.3	278	54.4	15.2	242.09
Ca^{2+} mg L^{-1}	130.15	130.15	144.15	255.15	242.15	164.15	166.15	163.15	95.35	165.62
Mg^{2+} mg L^{-1}	12.08	13.38	15.38	27.08	30.28	22.78	23.08	19.78	16.68	20.06
Na^{+} mg L^{-1}	3.71	7.18	35.18	29.08	46.98	63.58	68.98	47.88	17.48	35.56
FOG mg L^{-1}	4.4	17.6	18.8	38.0	72.0	21.6	33.2	16.4	9.6	25.73
TH mg L^{-1}	374.56	379.91	423.09	748.29	729.01	503.46	509.68	488.62	306.63	495.92
SAR	0.06	0.11	0.53	0.33	0.54	0.88	0.95	0.67	0.31	0.49

Table 5: Physiochemical Parameter Values for All Sampling Sites on 15th June 2015

	Sites									
Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**Mean**
Temp. °C	25.1	25.2	25.1	25.3	28.1	25.2	26.1	25.3	28.1	25.94
pH	7.2	7.37	7.15	7.09	7.29	7.36	7.51	7.53	7.73	7.36
EC µS cm^{-1}	724	1137	1499	1800	1378	1598	1461	1645	387	1292.1
TDS mg L^{-1}	463.2	727.8	959.1	1152.0	881.9	1023.0	935.0	1052.9	247.5	826.9
Turb. NTU	3.37	67.6	248	820	672	81.4	140.0	241	19.2	254.73
Ca^{2+} mg L^{-1}	112.15	119.15	172.15	233.65	164.15	182.15	173.15	205.15	39.75	155.72
Mg^{2+} mg L^{-1}	13.88	20.08	21.08	28.58	24.28	27.38	26.38	28.98	13.88	22.72
Na^{+} mg L^{-1}	4.44	78.98	96.98	75.53	70.08	92.38	76.88	69.28	14.88	64.38
FOG mg L^{-1}	5.6	16.8	27.2	42	75.2	40.8	29.6	24.4	11.2	30.31
TH mg L^{-1}	337.04	380.03	516.43	700.80	509.63	567.32	540.74	631.31	156.33	482.18
SAR	0.07	1.25	1.32	0.88	0.96	1.20	1.02	0.85	0.37	0.88

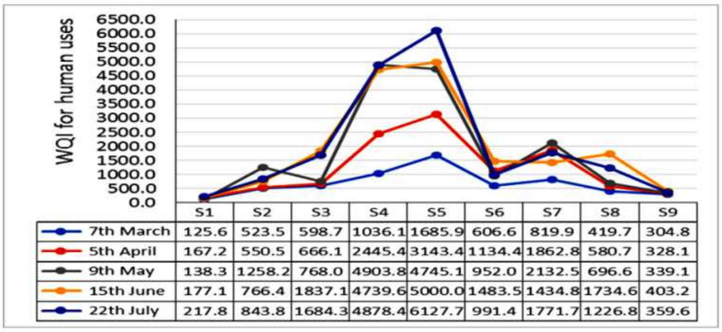
Table 6: Physiochemical Parameter Values for All Sampling Sites on 22nd July 2015

	Sites									
Parameters	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**Mean**
Temp. °C	25.3	25.5	26.1	26.7	28.6	25.3	26.8	26.7	29.3	26.70
pH	7.21	7.87	7.43	7.41	7.51	7.52	7.73	7.93	7.90	7.61
EC µS cm^{-1}	875	1239	1380	1965	4213	1743	1633	1439	487	1663.9
TDS mg L^{-1}	560.3	792.8	882.9	1257.9	2696.4	1115.5	1045.3	921.1	311.7	1064.9
Turb. NTU	5.01	79.2	225	796	887	78.2	184	139	18.6	268.00
Ca^{2+} mg L^{-1}	144.15	118.15	162.15	212.15	570.15	202.15	196.15	170.15	43.75	202.11
Mg^{2+} mg L^{-1}	15.78	24.18	21.68	30.08	72.78	30.48	30.08	27.78	20.98	30.42
Na^{+} mg L^{-1}	5.14	88.38	74.08	121.98	89.18	95.28	83.08	71.38	19.38	71.99
FOG mg L^{-1}	6.8	17.6	25.2	50.8	81.6	23.2	34.8	22	9.6	30.18
TH mg L^{-1}	424.73	394.40	493.94	653.31	1722.58	629.99	613.37	539.01	195.53	629.65
SAR	0.08	1.38	1.03	1.48	0.67	1.18	1.04	0.95	0.43	0.91

Table 7: Standard Value for Human Uses and Irrigation Purposes

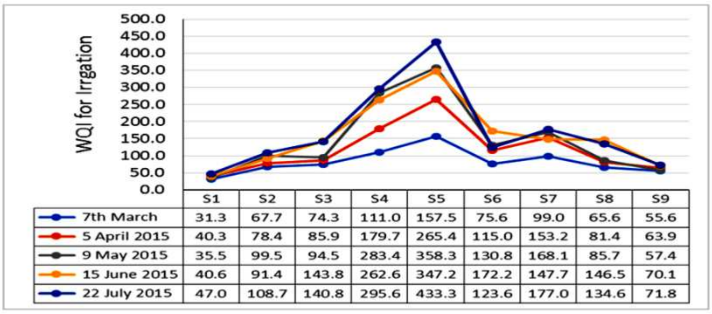
Parameters	Unit	Standard Value for Human Uses (A)	Standard Value for Irrigation (B)
Temp.	°C	25	30
pH	-	8.5	8.5
EC	$\mu S\ cm^{-1}$	1250	1500
TDS	$mg\ L^{-1}$	1000	1000
Turbidity	NTU	5	50
Ca^{2+}	$mg\ L^{-1}$	100	80
Mg^{2+}	$mg\ L^{-1}$	30	35
Na^{+}	$mg\ L^{-1}$	100	100
FOG	$mg\ L^{-1}$	2	10
TH	$mg\ L^{-1}$	300	500

Sources: (a) Standard values for human uses recommended by GOB (1997), NSWCC (2007), WHO (2004), AWQQ (1981), drinking-water standard IQS (2001), ICMR (1975), FEPA (1991). **(b)**Standard values for irrigation purposes recommended by GOB (1997), AWQQ (1981), FEPA (1991) and FAO (1985).



	S1	S2	S3	S4	S5	S6	S7	S8	S9
7th March	125.6	523.5	598.7	1036.1	1685.9	606.6	819.9	419.7	304.8
5th April	167.2	550.5	666.1	2445.4	3143.4	1134.4	1862.8	580.7	328.1
9th May	138.3	1258.2	768.0	4903.8	4745.1	952.0	2132.5	696.6	339.1
15th June	177.1	766.4	1837.1	4739.6	5000.0	1483.5	1434.8	1734.6	403.2
22th July	217.8	843.8	1684.3	4878.4	6127.7	991.4	1771.7	1226.8	359.6

Figure 2: Water Quality Index (WQI) Values for All Sampling Sites During 7th March 2015 to 22ndjuly 2015 for Human Uses



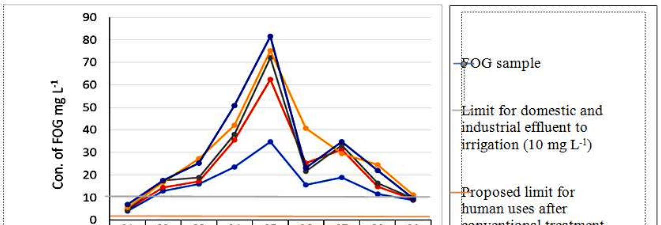
	S1	S2	S3	S4	S5	S6	S7	S8	S9
7th March	31.3	67.7	74.3	111.0	157.5	75.6	99.0	65.6	55.6
5 April 2015	40.3	78.4	85.9	179.7	265.4	115.0	153.2	81.4	63.9
9 May 2015	35.5	99.5	94.5	283.4	358.3	130.8	168.1	85.7	57.4
15 June 2015	40.6	91.4	143.8	262.6	347.2	172.2	147.7	146.5	70.1
22 July 2015	47.0	108.7	140.8	295.6	433.3	123.6	177.0	134.6	71.8

Figure 3: Water Quality Index (WQI) Values for All Sampling Sites During 7thmarch 2015 to 22nd July 2015 for Irrigation Purposes

Fat, Oil and Grease (FOG)

Contamination with oil and grease-like substances may affect the smell, taste of water and can cause technological problems in addition to health disorders (Fresenius *et al* 1988). The recorded value of Fat, oil and grease for Qalyasan stream at site (S1) was ranged from (4.0 mg L^{-1}) in March to (6.8 mg L^{-1}) in July (Figure 4). The FOG level values were much lower than other sites in the study area, this could be due to the location of site (S1) water resource in an upstream area with low population and less effected by domestic and industrial wastewater. Accordingly, the FOG values of

Qalyasan stream were found within the permissible limits for irrigation purposes and needs to treatment for human uses that were set by Liu (1999) and FEPA (1991). Liu (1999) stated that the desirable limit for FOG is 2 mg L^{-1} for human uses after conventional treatment and10 mg L^{-1} for irrigation. While the mean values of FOG for Qalyasan stream at sites (S2, S3 and S4) were (12.8, 16.0 and 23.6 mg L^{-1}) in March and (17.6, 25.2 and 50.8 mg L^{-1}) in July respectively,The high level of FOG found during July may be attributed to the discharge of wastewater from domestic activities or many sewage outlet disposal, oil refiner, industrial and agricultural activities. However it can be noted that the highest values for FOG was found in Tanjero River recorded at site (S5) and the values were ranged from 34.8 mg L^{-1} in March to 81.6 mg L^{-1} in July. This may be due to the position of Tanjero River that sink for high wastewater polluted with FOG from all effluent (untreated wastewater, landfilled, slaughterhouses and industrial area) of Sulaimani city. According to Ayers and Westcot (1976), FEPA (1991) and CEA (2001) So, the water at Tanjero River cannot be used for human uses and irrigation purpose. These results are in agreement with the results reported by Techobanglous and Franklin (1995), they found that the concentration of oil and grease in an untreated domestic wastewater is always in the range between 50 to 100 mg L^{-1}. The mean values of FOG at sites (S2 to S8) were (15.84 to 17.84 mg L^{-1}) were higher than the desirable concentrations for domestic water consumption recommended by WHO standard hence unfit for use as potable water unsafe. The highest mean values of FOG recorded were (38.0 and 65.2 mg L^{-1}) at sites (S4) and (S5) respectively, this increasing FOG values due to increasing in the high mean values of turbidity at sites (S4) and (S5) were (584.28 and 537.2 NTU) respectively. This lead to the high amount of untreated wastewater discharged into Tanjero River. Generally, the untreated wastewater from kitchens, slaughter houses, landfilled, restaurants and industrial area may content high amount of FOG (Steel and McGhee 1979) and (Meenambal*et al* 2005), Unspecified amount of polluted water with (FOG) in Tanjero River was used for irrigation intensively and without any treatment for wastewater may by damage the soil (IPD 2008), Also FOG can block irrigation systems, and more importantly block soil pores subsequently causing anaerobic conditions in the soil which will both reduce plant growth and potentially create odors, therefore reduce transmit water in soil (Travis*et al* 2008) and (IPD 2008). The land irrigated along Tanjero River, therefore, lead to degraded soil quality. The concentration values of FOG inDarbandikhan reservoir were ranged between 8.8 and 9.6 mg L^{-1} and slightly higher than desirable limit may be due to the discharge of the high amount of FOG from Qalyasan stream and Tanjero River that polluted with untreated wastewater and run off come from Sulaimani city. The FOG forms a layer on the surface of the water in Darbandikhan reservoir that decreases dissolved oxygen and increases COD and BOD, and cause ecology damages to water body (Sahu*et al*2007). Therefore depleted dissolved oxygen in Darbandikhan reservoir in summer may be lead to killing fish that become a phenomenon in recently years (Iraqi Twin River Nature Iraq/Twin Rivers Institute Work 2008). Accordingly, the FOG values of Darbandikhan reservoir were found within the permissible limits for irrigation purposes only.



	S1	S2	S3	S4	S5	S6	S7	S8	S9
7th March	4	12.8	16	23.6	34.8	15.6	18.8	11.6	8.8
5th April	4.8	14.4	17.2	35.6	62.4	25.2	31.2	14.8	9.2
9th May	4.4	17.6	18.8	38	72	21.6	33.2	16.4	9.6
15th June	5.6	16.8	27.2	42	75.2	40.8	29.6	24.4	11.2
22nd July	6.8	17.6	25.2	50.8	81.6	23.2	34.8	22	9.6

Figure 4: FOG Concentration during the Study Period for All Sites Compared with Proposed Limits

CONCLUSIONS

This study shows a clear decrease in water quality with increased the concentration of FOG during the summer period. In Qalyasan stream (S1) clearly indicates that the stream water can be used for human uses after conventional treatment and irrigation purposes without any treatment. The FOG in Tanjero River were higher than the desirable limit, andWQI clearly indicates degradation in water quality and unsuitable for the human uses and irrigation purposes in summer. It has been concluded that discharging of domestic and industrial wastewater were the main factors for contaminating Tanjero River. The water quality of Darbandikhan reservoir was unsuitable for human uses due to Tanjero River linking that polluted with untreated wastewater. High environmental impact on Darbandikhan reservoir, Tanjero River and Qalyasan Stream resulting during the high amount discharge of (FOG) from sites (S4 and S5), this needs to be given the desired attention and technique to removal (FOG) in these water resources.

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